TECHNICAL RESEARCH NOTE 111

Validation of the Army Fixed-Wing Aptitude Battery Against Success in ROTC Flight Training

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VALIDATION OF ARMY FIXED-WING APTITUDE BATTERY AGAINST SUCCESS IN ROTC FLIGHT TRAINING

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Submitted by

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May 1961

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PREFACE

The Army Fixed-Wing Aptitude Battery is designed for use in identifying men who are likely to complete successfully a military flight training program and become useful Army pilots of fixed-wing aircraft. The battery has been used operationally since 1956 in selecting trainees from among applicants for the Army Fixed-Wing Flight Training Program. Research establishing its validity for that purpose has been described in Human Factors Research Branch Technical Research Note 110. The present Research Note describes research to evaluate the AFWAB for use in screening student applicants for the Army's Reserve Officer Training Corps Flight Training Program.

BRIEF

VALIDATION OF ARMY FIXED-WING APTITUDE BATTERY AGAINST SUCCESS IN ROTC FLIGHT TRAINING

Requirement:

DCSPER requested evaluation of the Army Fixed-Wing Aptitude Battery (AFWAB) for use in selecting trainees for the ROTC Flight Training Program (FTP).

Procedure:

The battery was administered to samples of FTP applicants drawn from the ROTC classes of 1956-57, 1957-58, and 1958-59. AFWAB scores were analyzed in relation to successful completion of the ROTC Flight Training Program.

Findings:

The AFWAB was found to have useful validity for selecting trainees from among ROTC applicants qualifying for flight training. All component tests were found to contribute to the selective efficiency of the battery. Unit weighting of component scores was found to be as effective as optimal statistical weighting.

Utilization of Findings:

Continued operational use of the complete battery is warranted. Operational use will be aided by tables provided for establishing cutting scores on the battery in terms of trainee requirements and allowable attrition rate for a given selection period.

VALIDATION OF ARMY FIXED-WING APTITUDE BATTERY AGAINST SUCCESS IN ROTC FLIGHT TRAINING

CONTENTS

TABLES

FIGURES

VALIDATION OF ARMY FIXED-WING APTITUDE BATTERY AGAINST SUCCESS IN ROTC FLIGHT TRAINING

The Army ROTC Flight Training Program, authorized by law in 1956, is designed to provide instruction in basic ground and in-flight fundamentals to meet minimum requirements of the Federal Aviation Agency (FAA) and to qualify students for FAA private pilot certificates. The objective is to create a reserve pool of qualified pilots who can be utilized in the event of a national emergency.

The ROTC Flight Training Program is extracurricular. That is, the primary purpose of the Army ROTC program--to develop qualified Army officers--is not modified to allow for flight training. The training, open to qualified applicants at selected ROTC colleges and universities, meets the FAA's requirements of 35 hours of ground instruction and 36 1/2 hours of flight instruction, including an FAA final flight check. An additional three hours of flight instruction is authorized to meet unforeseen contingencies or to provide supplemental instruction if necessary Army ROTC flight training is given under contract by flying schools approved by the FAA.

ROTC flight training may further serve as a selection device and as useful preparation for the active Army's Fixed-Wing Flight Training Program. The experience of the Air Force bears out this assertion. In a group of students at the Air Force flying school, there were fewer failures for reasons of flying deficiency among men who had trained under the AF ROTC Flight Instruction Program than among men who had not so trained (4% vs 19%) (Tucker, 1954). In fact, the Air Force has found previous flying experience in itself to be positively related to success in pilot training (Cox and Mullins, 1959).

PURPOSES OF THE PRESENT STUDY

The Army Fixed-Wing Aptitude Battery (AFWAB) was adapted by the Human Factors Research Branch from the Officer Qualification Test used by the Air Force in the selection of aviation cadets. The Human Factors Research Branch was requested by DCSPER to evaluate the battery as a selection instrument for students applying for Army ROTC flight training. The purposes of the present study were to determine the validity of the battery in relation to success in the Army ROTC Flight Training Program, to provide information which could be used to establish cutting scores appropriate to the Army's training requirements for a given year, and to study the effect of weighting the tests by a multiple correlation procedure.

PROCEDURE

POPULATION AND SAMPLES

The battery is intended for use in selecting trainees for the ROTC Flight Training Program from among ROTC students who apply and who meet the general standards for acceptance. Applicants must be recommended by the Dean or by the Professor of Military Science and Tactics on the basis of class standing. They must have completed, or be enrolled in, the advanced Military Science course (MS IV). They must meet Class 1 physical standards for flying. There are other administrative requirements such as parental consent if the applicant is under 21 and agreement on the part of the applicant to serve three years on active duty if accepted.

The Army Fixed-Wing Aptitude Battery (AFWAB) was administered experimentally to samples of students applying for FTP during the years 1956-57, 1957-58, and 1958-59. Men were tested in ROTC Summer Camp following their junior year and prior to entrance into flight training. The sample for the primary evaluation analysis consisted of 1245 applicants accepted for FTP during the three years. Total AFWAB score and scores on component tests were evaluated for effectiveness in discriminating between successful and unsuccessful ROTC-FTP trainees. Criterion information was based on reports submitted by the schools to the Human Factors Research Branch as each class completed training.

Analyses were also conducted on subsamples drawn from the yearly classes. Rejected applicants (N = 1325) constituted a second sample used only to test the representativeness of the acceptee sample in terms of AFWAB scores. Summary information about the samples is provided in Table A-1 of the Appendix.

VARIABLES

Criterion Variable. Pass-Fail FTP, a dichotomous variable consisting of students who successfully completed the course versus students who failed for any reason. Students who for any reason did not complete the course were considered failures.

Predictor Variables. The predictors consisted of the five tests of the Army Fixed-Wing Aptitude Battery and the AFWAB composite score:

1. Background Inventory Test, DA Form 6234. Consists of 30 five-choice items dealing with the individual's family, education, hobbies, and employment background. The time limit is ten minutes. Scoring formula is rights only.

2. Aeronautical Information Test, DA Form 6235. Consists of 30 five-choice items dealing with the individual's general and technical knowledge of aeronautical information. The time limit is twenty minutes. Scoring formula is rights minus 1/4 wrongs.

3. Mechanical Principles Test, DA Form 6236. Consists of 30 five-choice items dealing with the ability of the individual to understand general mechanical principles. The time limit is thirty minutes. Scoring formula is rights minus 1/4 wrongs.

4. Aircraft Orientation Test, DA Form 6237. Consists of 28 five-choice picture items dealing with the ability of the individual to visualize the relationship between an airplane and the territory over which it flies. The test differs from its prototype in the Air Force Officer Qualifying Test in that silhouettes of planes are used instead of photographs. The time limit is ten minutes. Scoring formula is rights minus 1/4 wrongs.

5. Flight Visualization Test, DA Form 6238. Consists of 28 five-choice picture items dealing with the ability of the individual to visualize airplane maneuvers. In this test also, silhouettes were substituted for the photographs used in the Air Force test. The time limit is thirty minutes. Scoring formula is rights minus 1/4 wrongs.

6. AFWAB Composite Score. Obtained by summing the final scores on each of the five subtests. The final score on each subtest consists of the raw score less the correction for guessing.

SAMPLING CONSIDERATIONS

Decision to base evaluation of the battery on analysis in the total sample was reached primarily through study of subsamples drawn from each of the three academic classes. The total number of applicants and enrollees as well as the total number of schools participating in FTP was much larger in each of the second two years than in the first, since during the first year there was a lag in getting the program started in many schools. The absolute number successfully completing the course was also greater in the second two years. The percentage passing the course declined in successive academic years from 88% to 76% to 69%.

That these figures are somewhat biased is indicated by a report submitted to Congress by the Chief, U. S. Army Reserve and ROTC Affairs (CARROTC). According to this report, presumably based on complete data from participating schools, the percentages passing for each of the three academic years in question were 80%, 77%, and 74%. Also, in view of CARROTC's figures, the downward trend over the three years was less than that indicated by the experimental data. (Two reasons may be advanced for the difference in the two sets of figures: First, in the case of some schools, AFWAB scores of students who did not participate in the Summer Camp experimental testing were not included in data forwarded to the Human Factors Research Branch. Second, AFWAB scores for the 1958-59 class were received from ten schools after the cut-off date for the analysis.) For the total three-year period, however, CARROTC reported 77% passing, whereas the corresponding figure in the sample for the present study was 75%. The difference should not have a very large influence on the validity coefficient for the total sample.

Validity coefficients for AFWAB total score in the three classes were .39, .26, and .32. Results for component tests were also consistent in direction. In fact, only one validity coefficient--that for the Aeronautical Information Test in the 1956-57 subsample (r_{bis} = .05)--was not significant. Intercorrelation coefficients in the three subsamples were not markedly different from those found in the total sample.

RESULTS

VALIDITY

The validity coefficient[1] of the AFWAB for the total sample was .32 (Table 1). After correction for restriction in range[2], the coefficient increased to .33. Each of the component tests yielded significant correlation with the pass-fail criterion (r's ranged from .20 to .24). Intercorrelation coefficients of the component tests ranged from a low of .11 between the Background Inventory and the Aircraft Orientation Test to a moderate level of .52 between the Aircraft Orientation Test and the Flight Visualization Test. In view of these coefficients, elimination of any of the component tests from the battery would not appear efficient.

The selective efficiency of the AFWAB is illustrated in Figure 1 which is based on the data shown in Table 2. The sample of FTP trainees was ranked on AFWAB score and divided into quarters. The percentage passing the Flight Training course was computed for each quarter. A substantial increase in the percentage of students successfully completing FTP was observed in moving from the bottom to the top quarter.

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[1] Biserial correlation coefficient converted from point-biserial correlation coefficient.

[2] Bases for acceptance for FTP used by the various schools were not known. Reports from the schools showed that three percent of those rejected were rejected because of low AFWAB scores. The S. D. on AFWAB for the sample of acceptees was 19.85; for the sample of rejectees, 20.63. The difference is significant at approximately the 5% level (F = 1.08). The means for the two samples were 54.50 and 52.09 respectively (significant at the 1% level). However, the validity coefficient for the AFWAB corrected for restriction in range was practically the same as the uncorrected coefficient.

Table 1

VALIDITY COEFFICIENTS AND INTERCORRELATION COEFFICIENTS OF AFWAB COMPONENT AND TOTAL BATTERY SCORES OF ROTC-FTP SAMPLE (N = 1245)

	Variables	Mean	S. D.	Coefficients						
1.	Background Inventory	9.77	3.46	1						
2.	Aeronautical Information	5.47	4.68	.18	2					
3.	Mechanical Principles	15.42	6.01	.17	.38	3				
4.	Aircraft Orientation	11.51	6.37	.11	.26	.42	4			
5.	Flight Visualization	12.34	8.07	.16	.30	.49	.52	5		
6.	AFWAB Total Score	54.50	19.85	.37	.59	.76	.74	.82	6	
7.	Pass-Fail Criterion	.75	.43	.20	.20	.21	.23	.24	.32	7[a]
						R = .34[b]				

[a] Validity coefficients are biserial coefficients converted from point biserial coefficients.

[b] Multiple R based on optimally weighted component tests, not corrected for shrinkage.

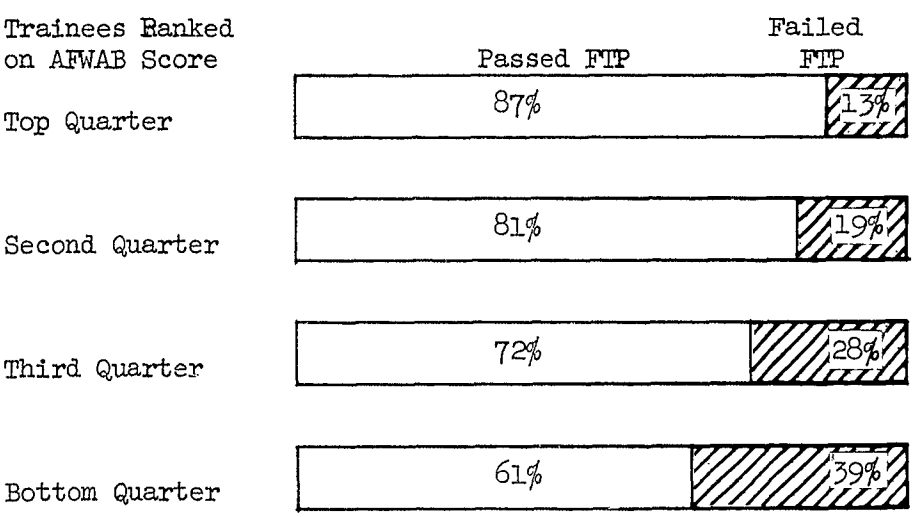

Figure 1. Comparative success in ROTC FTP of 1245 trainees ranked on AFWAB score for academic years 1956-57, 1957-58, and 1958-59. (N = 1245)

Table 2

RELATION OF PERFORMANCE ON THE AFWAB TO SUCCESS IN THE ARMY ROTC-FLIGHT TRAINING PROGRAM BY ENROLLED STUDENTS FOR ACADEMIC YEARS 1956-57, 1957-58, AND 1958-59 (N = 1245)

Qtr. of Group on AFWAB	N	Number passing	Number failing	% passing
Top Quarter	313	272	41	87
Second Quarter	312	254	58	81
Third Quarter	310	223	87	72
Bottom Quarter	310	188	122	61
Total Group	1245	937	308	75

OPTIMAL VERSUS UNIT WEIGHTING

Unit weighting of the component tests of the AFWAB resulted in a validity coefficient of .32; with optimal weighting, the coefficient was .34. When shrinkage was estimated, the multiple correlation coefficient dropped from .34 to .33. In brief, the method of optimal weighting resulted in no better predictive efficiency than the administratively less cumbersome unit-weighting.

CUTTING SCORE DATA

Using the unit-weighted validity coefficient, data on FTP success of the 1245 trainees in the sample were analyzed to show the estimated effect of various AFWAB cutting scores on the attrition rate. Tables based on this analysis are provided in the Appendix. Table A-4 shows, for trainees who would have been accepted under a given AFWAB cutting score (had the AFWAB been used operationally), the percentage passing and the percentage failing the course. Table A-5 provides like information on trainees who would have been rejected under various AFWAB cutting scores.

CONCLUSIONS

The validity coefficient of .33 indicates that the AFWAB is a fairly effective instrument for predicting success in the Army ROTC

Flight Training Program. Validity and intercorrelation coefficients obtained for component tests of the AFWAB indicate that it would not be efficient to eliminate any of the tests from the battery. The unit-weighted system was used in establishing cutting score information since it proved to be as good a predictor of flight training success as the administratively more cumbersome optimally weighted score.

OPERATIONAL USE OF AFWAB

The quality of ROTC flight-trained men would probably improve if selection from among qualified applicants were accomplished by a central authority on the basis of AFWAB scores. To meet the minimum quota of five students from each participating institution, the five highest ranking men from a given school would be assigned to that school. The remaining pool of applicants would then be ranked on the basis of AFWAB score; selection would be made from the top down until the needs of the program had been met. The selected applicants would then be assigned to their respective schools. This would insure that within the practical limits of the program applicants would be selected optimally in terms of AFWAB score. In the present system, where each individual school uses the AFWAB, the most effective use is for each school to rank its qualified applicants in terms of AFWAB score and select from the top down.

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1. OCARROTC. Report to Congress on the Progress of the Army ROTC Flight Training Program, 1 August 56 to 1 December 59. CARROTC 353/Aviation. February 1960.

2. Cox, J. A. and Mullins, C. J. Evaluation of Light Plane Training Among AFROTC Student Officers. Technical Note WADC-TN-59-43. Personnel Laboratory, Wright Air Development Center, Air Research and Development Command, United States Air Force, Lackland Air Force Base, San Antonio, Texas. July 1959.

3. Tucker, J. A., Jr. Use of Previous Flying Experience as a Predictor Variable. Research Bulletin AFPTRC-TR-54-71. Air Force Personnel and Training Research Center, Lackland Air Force Base, San Antonio, Texas. December 1954.

APPENDIX

Table A-1

BREAKDOWN OF SAMPLES OF ROTC FLIGHT TRAINING PROGRAM APPLICANTS FOR EACH OF THREE ACADEMIC YEARS AND FOR THREE-YEAR PERIOD

Description	Academic Year			
	1956-57	1957-58	1958-59	Combined Samples
Number of Universities Participating	25	55	56	63
Total Number of applicants with AFWAB Scores	460	1130	1091	2681
Number of Applicants Accepted for Training				
a. Number accepted and trained	209	529	507	1245[a]
b. Number accepted but not trained	43	52	17	112
c. Total number accepted	252	581	524	1357
Number of Applicants Rejected for Training because:				
a. Low scores on aptitude battery	11	3	23	37
b. Physical disqualification	164	309	397	870
c. Other reasons	33	237	147	417
Total Number of Applicants Rejected	208	550	567	1325
Number of Students who Passed Course	184	403	350	937
Percentage of Students who Passed Course	88%	76%	69%	75%
Number of Students who Failed Course	25	126	157	308

[a]Sample on which validity analysis was conducted.

Table A-2

MEANS AND STANDARD DEVIATIONS FOR AFWAB COMPONENT TEST AND TOTAL SCORE FOR ACCEPTED AND FOR REJECTED ROTC FLIGHT TRAINING PROGRAM APPLICANTS FOR EACH OF THREE ACADEMIC YEARS AND FOR THREE-YEAR PERIOD

TEST	1956-59				1956-57				1957-58				1958-59			
	Total Sample															
	Accepted Applicants (N = 1245)		Rejected Applicants (N = 1325)		Accepted Applicants (N = 208)		Rejected Applicants (N = 208)		Accepted Applicants (N = 529)		Rejected Applicants (N = 550)		Accepted Applicants (N = 507)		Rejected Applicants (N = 567)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Background Inventory	9.77	3.46	9.48	3.47	9.85	3.38	9.78	3.60	9.52	3.52	9.48	3.24	10.00	3.42	9.37	3.64
Aeronautical Information	5.47	4.68	5.19	4.72	6.00	4.45	5.47	4.57	5.59	4.76	5.20	5.05	5.12	4.65	5.08	4.44
Mechanical Principles	15.42	6.01	15.12	6.37	17.19	5.74	16.79	5.87	15.50	6.18	14.62	6.54	14.59	5.42	14.99	6.27
Aircraft Orientation	11.51	6.37	10.76	6.33	13.56	6.36	13.09	6.87	11.78	6.39	11.10	6.25	10.38	6.11	9.58	5.91
Flight Visualization	12.34	8.07	11.54	8.05	13.66	7.62	13.36	7.83	12.59	8.14	11.74	8.19	11.52	8.08	10.68	7.87
AFWAB Total Score	54.50	19.85	52.09	20.63	60.27	19.14	58.49	20.48	54.99	20.47	52.14	20.80	51.61	18.89	49.69	20.00

Table A-3

VALIDITY AND INTERCORRELATION COEFFICIENTS OF AFWAB COMPONENT TEST AND TOTAL BATTERY SCORES OF ROTC FLIGHT TRAINEE SAMPLES FOR EACH OF THE THREE ACADEMIC YEARS

	Variables	Mean	S. D.	Coefficients						
				Total Sample (A, B, and C) 1956-57, 1957-58, 1958-59 (N = 1245)						
1.	Background Inventory	9.77	3.46	1						
2.	Aeronautical Information	5.47	4.68	.18	2					
3.	Mechanical Principles	15.42	6.01	.17	.38	3				
4.	Aircraft Orientation	11.51	6.37	.11	.26	.42	4			
5.	Flight Visualization	12.34	8.07	.16	.30	.49	.52	5		
6.	AFWAB Total Score	54.50	19.85	.37	.59	.76	.74	.82	6	
7.	Pass-Fail Criterion	.75	.43	.20	.20	.21	.23	.24	.32	7[a]
				R = .34[b]						
				Sample A 1956-57 (N = 209)						
1.	Background Inventory	9.85	3.38	1						
2.	Aeronatical Information	6.00	4.45	.23	2					
3.	Mechanical Principles	17.19	5.74	.18	.41	3				
4.	Aircraft Orientation	13.56	6.36	.00	.22	.42	4			
5.	Flight Visualization	13.66	7.62	.14	.28	.51	.57	5		
6.	AFWAB Total Score	60.27	19.14	.34	.58	.77	.74	.83	6	
7.	Pass-Fail Criterion	.88	.32	.24	.05	.36	.29	.34	.39	7[a]
				R = .47[b]						

Table A-3 (cont'd)

	Variables	Mean	S. D.	Coefficients						
				Sample B 1957-58 (N = 529)						
1.	Background Inventory	9.52	3.52	1						
2.	Aeronautical Information	5.59	4.76	.20	2					
3.	Mechanical Principles	15.50	6.18	.23	.38	3				
4.	Aircraft Orientation	11.78	6.39	.20	.24	.43	4			
5.	Flight Visualization	12.59	8.14	.25	.32	.48	.53	5		
6.	AFWAB Total Score	54.99	20.47	.45	.58	.76	.74	.82	6	
7.	Pass-Fail Criterion	.76	.43	.20	.16	.13	.22	.19	.26	7[a]
						R = .29[b]				
				Sample C 1958-59 (N = 507)						
1.	Background Inventory	10.00	3.42	1						
2.	Aeronautical Information	5.12	4.65	.15	2					
3.	Mechanical Principles	14.59	5.42	.13	.37	3				
4.	Aircraft Orientation	10.38	6.11	.06	.28	.40	4			
5.	Flight Visualization	11.52	8.08	.07	.27	.50	.47	5		
6.	AFWAB Total Score	51.61	18.89	.31	.59	.78	.72	.80	6	
7.	Pass-Fail Criterion	.69	.46	.22	.25	.22	.16	.24	.32	7[a]
						R = .36[b]				

[a]Validity coefficients are biserial coefficients converted from point biserial coefficients.

[b]Multiple R based on optimally weighted component tests, not corrected for shrinkage.

Table A-4

THE RELATION OF VARIOUS AFWAB CUTTING SCORES TO ATTRITION DURING TRAINING FOR APPLICANTS ACCEPTED FOR THE ROTC FLIGHT TRAINING PROGRAM (N = 1245)

HYPOTHETICAL		ACTUAL	
AFWAB Cutting Score	% Accepted	Passing[a]	% Failing
22	95	76	24
28	90	78	22
32	85	79	21
36	80	79	21
38	75	80	20
42	70	81	19
45	65	82	18
48	60	83	17
51	55	83	17
54	50	84	16
57	45	84	16
59	40	85	15
62	35	86	14
65	30	86	14
68	25	87	13
71	20	87	13
76	15	86	14
81	10	89	11
88	5	88	12

[a]Percent of those accepted for training. For example, if a cutting score of 54 on AFWAB were adopted, 50% of the applicant group would have been accepted for training. In this sample, 84% of the 50% actually passed flight training.

Table A-5

THE RELATION OF VARIOUS AFWAB CUTTING SCORES TO ATTRITION DURING TRAINING FOR APPLICANTS REJECTED FOR THE ROTC FLIGHT TRAINING PROGRAM (N = 1245)

HYPOTHETICAL		ACTUAL	
AFWAB Cutting Score	% Rejected	Passing[a]	% Failing
22	5	40	60
28	10	52	48
32	15	54	46
36	20	59	41
38	25	60	40
42	30	63	37
45	35	63	37
48	40	64	36
51	45	66	34
54	50	66	34
57	55	68	32
59	60	69	31
62	65	70	30
65	70	70	30
68	75	71	29
71	80	72	28
76	85	73	27
81	90	74	26
88	95	75	25

[a] Percent of those rejected from training. For example, if a cutting score of 54 were adopted, 50% of the rejected group would have been accepted for training. In this sample, 66% of the 50% actually passed flight training.

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Human Factors Research Branch, TAG R and D Command, DA
VALIDATION OF ARMY FIXED-WING APTITUDE BATTERY AGAINST SUCCESS IN ROTC FLIGHT TRAINING by Nathan Rosenberg, Donald M. Skordahl, and Harry Kaplan. May 1961. Rept. on Helicopter C-21 Proj. 21 pp. incl. illus. tables, 3 Ref. (HFRB Technical Research Note, No: 111)
(DA Project 2L95-60-001) Unclassified Report

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The Army Fixed-Wing Aptitude Battery (AFWAB), used operationally since 1956, is designed for use in identifying men who are likely to successfully complete a military flight training program and become useful Army pilots of fixed-wing aircraft. To evaluate the AFWAB for use in screening student applicants for Army ROTC-FTP, the battery was administered experimentally to 1245 FTP applicants, drawn from samples of academic years 1956-57, 1957-58, and 1958-59. Total AFWAB score and scores on component tests were analyzed in relation to successful completion of the ROTC Flight Training Program. Validity and intercorrelation coefficients obtained indicate that the AFWAB is an effective instrument for trainee selection. All component tests were found to contribute to the selective efficiency of the battery. Unit weighting of component scores was found to be as effective as the administratively more cumbersome optimally weighted score. In view of the findings, continued operational use of the complete battery is warranted.

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Human Factors Research Branch, TAG R and D Command, DA
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